“MICROBIAL FUEL CELLS, A GLANCE AT THE FUTURE”

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Autonomous University of Barcelona, Bellaterra 2013.

“We must develop a <u>new energy platform</u> able to both produce enough energy and reduce CO_2 emissions”.
Microbial Fuel Cells (MFC) represent the newest approach for generating electricity.

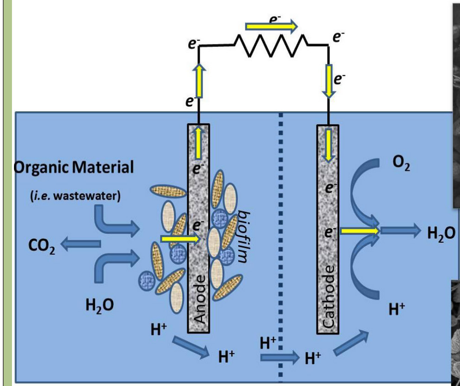
MICROBIAL FUEL CELL BASIC COMPONENTS

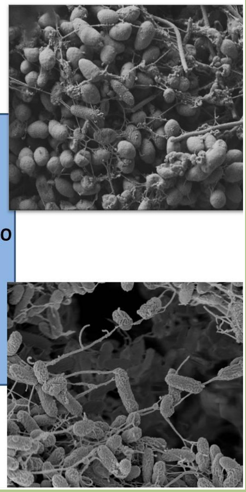
Anode

- Electrode material: carbonaceous or metallic.
- Carbonaceous materials are better for the bacterial growth (biofilm formation): must be biocompatible.
- Brush structure is recomanable (increases the surface area).
- Anaerobic conditions; O_2 inhibits electricity generation.
- Bacteria oxidize organic matter realising electrons to the anode and protons to the solution.

Exoelectrogenic Mechanisms

- **Direct contact.**
- **Nanowires**: conductive appendages produced by bacterium.
- **Endogenous and artificial redox mediators.**





Anode reaction: $CH_3COO^- + 2H_2O \rightarrow 2CO_2 + 7H^+ + 8e^-$
Cathode reaction: $O_2 + 4e^- + 4H^+ \rightarrow 2H_2O$

Figure 1. Schematic of the basic components of a Microbial Fuel Cell. Below the reactions that take place. The flow of protons throught the membrane create a potential difference that will generate the current. In the right side there are two pictures taken by electronic microscope of the microbes that create the biofilm in the anode. In both we can appreciate the nanowires they use to transfer electrons to the anode (1).

Cathode

- Main electrode material: platinum or carbon.
- Types of cathode:
  - Aqueous cathode: oxygen is not used at the cathode. Ferricyanide, the most common aqueous cathalyst.
  - Air-cathode: open to the air, no need of aeration.
  - Bio-cathode: bacteria are the catalysts.

Membranes

- Separators that only allow the transfer of protons from anode to cathode.
- Important for the power output
- Membrane-less configuration would increase O_2 in the anode.
- Nafion ® is widely used.

MICROBIAL FUEL CELL TECHNOLOGY APPLIED TO THE PRESENT

Objectives

- Analyze the application of MFC in a house:
  <u>Could it be an electrically self-sufficient building</u>?
- Analyze the application of MFC technology in a wastewater treatment plant of a 10,000 people urban core.
  <u>How much electricity would it generate</u>?
  <u>Would it be enough for the street lighting? and for the wastewater plant running</u>?

Technological need

The MFC design must:

- Present a feasible MFC design.
- Be scalable to large dimentions.
- Have a flow pattern to be able to work under real conditions.
- Be made of inexpensive materials.

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Hybrid up-flow reactor configuration (Anaerobic digestor + MFC techonology)
- Air-cathode made of commercial 60wt.% Pt/C.
- Anode composed by graphite discs

(2)

Design

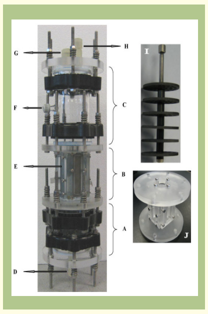

Figure 2. Photograph of a hybrid MFC. (A) Anaerobic digestion zone; (B) open air cathode single-chambered MFC zone; (C) clarifier zone; (D) inlet of the reactor; (E) open air cathodes; (F) out-let of the reactor; (G) Gas sampling port; (H) reference electrode placing port; (I) porous anode configuration with graphite discs; and (J) polyacrylate plastic block containing the electrodes.

Volume: 1,100mL (800mL net volume)
Hydraulic Retention time: 7h
Total anode surface: 54 cm^2
Coulombic Efficiency(CE): 20.8%
Current: 2,278mA/m^2 (2)

Figure 3. MFC system installed in a three people household. It consists of two elements both under the ground. The two elements are a buffer tank that will store the water and using a valve will pump it, with a regular flow rate, to the hybrid-up-flow MFC. This way it will avoid the fluctuations of the wastewater generation during the day. No agitation will be needed because the height difference will contribute to the homogenization of its content every time the wastewater arrives to the tank. There will be a closed water circuit and electricity net [Sketch created by Google SketchUp version 8].

Results & Conclusions

	3 people household	10,000 people urban core
MFC Volume	0.126 m^3	420 m^3
Anode surface	0.63 m^2	2,100 m^2
Power/year	25.24 kWh/y	84,131.49 kWh/y

- MFC volumes required to treat the flow rate of water (0.144m^3/d·person) (3) are feasible.
- Energy generated by the <u>3-people-MFC</u> only accounts for the **0.15%** of the house electricity consumption (17,012 kWh/house) (4).
- Energy generated by the <u>wastewater treatment (WWT) plant</u> could supply the elecricity of 5 detached houses. Furthermore, it accounts for the **7.25%** of the total demand of energy for the street lightning of this urban core (116 kWh/person· year) (5).
- In the case <u>CE was 100%</u>, the energy produced by WWT plant could represent the **25.9%** of demanded electricity for street lightning and **61.3%** of the energy required to run the WWT plant (49kWh/person·year) (6) what could suppose a great advance in the world of the wastewater treatment.

<u>To conclude, further investigation is needed to increase CE and, thus, make profit of the benefits that this amazing technology can offer to us.</u>

References: *(1) Wanger G. Electrogenic Bacteria Overview [Internet]. 2012. (2) Katuri KP, Scott K. Electricity generation from the treatment of wastewater with a hybrid up-flow microbial fuel cell. Biotechnology and bioengineering. 2010 Sep 1;107(1):52–8. (3) Instituto Nacional de Estadística. 2012. Available from: http://www.ine.es/. (4) IDAE. Proyecto Sech-spahouse. Análisis del consumo energético del sector residencial en España. 2011. (5) Ministerio de Economía y Competitividad. INVEST IN SPAIN “Alumbrado público”. 2011. (6) Instituto para la Diversificación y Ahorro de Energia. Estudio de Prospectiva. Consumo Energético en el sector del agua. 2011.*

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